# Minimally Invasive Access Cavity Vs Traditional Access Cavity: An Experimental Study

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**Abstract**

**Introduction:** Conservative endodontics aims to preserve dental tissues as much as possible while ensuring adequate access to the root canal system. Conservative access cavities (CACs) represent an approach designed to minimize dentin removal during endodontic treatment.

**Methods:** This experimental study was conducted on 30 mandibular molars. CACs were prepared using a protocol combining CBCT imaging, optical magnification, and ultrasonic tips to ensure accurate planning and controlled preparation. Residual dentin preservation and procedural complications were evaluated.

**Results:** Volumetric analysis demonstrated good preservation of dental tissues, with slight over-preparation observed in only 5 cases. No instrument fracture was reported during the study.

**Discussion:** The results confirm the potential of CACs to reduce tissue loss while maintaining adequate endodontic access. CBCT plays an essential role in three-dimensional anatomical analysis and preoperative planning, whereas optical magnification and ultrasonic tips improve operative precision. This approach may contribute to optimizing clinical outcomes in minimally invasive endodontics.

## 1. Introduction

Access cavity preparation represents a fundamental clinical step in endodontic treatment and largely determines its success (1,2). It provides access to the pulp chamber, allows identification of canal orifices, and ensures effective cleaning and disinfection of the root canal system while preserving as much coronal tooth structure as possible. An inadequate design may lead to iatrogenic errors and compromise treatment prognosis (3,4).

Technological advances, particularly in magnification and illumination systems (loupes and operating microscopes), as well as modern imaging techniques, have contributed to the development of minimally invasive endodontics. This approach aims to preserve the maximum amount of healthy dental tissue while improving diagnostic and therapeutic accuracy (1,5).

In this context, new concepts of conservative access cavities have been introduced by **Clark and Khademi** (6,7), with the objective of minimizing tissue removal. However, their implementation requires a delicate balance between eliminating obstacles to canal entry and preserving dental structures (8).
Therefore, this study aims to evaluate the clinical relevance of conservative access cavities compared with traditional access cavities, with a focus on tissue preservation. It is based on the preparation of conservative access cavities in 30 mandibular molars, while analyzing their advantages, limitations, and the contribution of preoperative digital imaging and magnification devices in optimizing clinical management.

## 2. Materials and methods

### 2.1 Ethical approval:

This experimental study was conducted at the Faculty of Dentistry of Casablanca on healthy mandibular first molars extracted for various reasons and stored in saline solution. All procedures complied with current ethical standards and the Declaration of Helsinki, including sample anonymization and informed patient consent. The study protocol was validated based on a literature review to ensure compliance with regulatory requirements.

### 2.2 Study design and sample size:

Based on data from the literature, a sample size of 30 mandibular molars was selected for this experimental study.

### 2.3 Inclusion and exclusion criteria:

The inclusion criteria consisted of healthy mandibular first molars with normal roots, a mesio-buccal (MB) canal curvature below 30°, no previous endodontic treatment, and proper preservation status.
The exclusion criteria included teeth with major anatomical abnormalities, poor preservation, caries or resorption, crown or root fractures, as well as complex root anatomy.

### 2.4 Experimental procedure and essential tools for the preparation of CACs

**Step 1: Preoperative CBCT evaluation**

Each 15 molars were scanned using a VATECH CBCT system (field of view: 16 × 9 cm) to obtain accurate images. The analysis enabled the planning of conservative access cavity outlines by determining the most tissue-preserving pathway toward each canal orifice. The pulp chamber floor-to-roof distance and the curvature of the mesio-buccal (MB) canal were also measured. These data were recorded as reference values for postoperative measurements.
CBCT provides a precise 3D analysis of the root canal anatomy, allowing accurate planning of conservative access cavities. Khademi et al. (2017) described an image-guided access approach based on emergence profiles, highlighting the importance of CBCT compared with 2D imaging (34).

**Step 2: Preparation of CACs**

Conservative access cavities were prepared using a standardized technical setup including magnification devices (operating microscope or loupes), rotary instruments (diamond and tungsten carbide burs, finishing burs, and Gates-Glidden drills), diamond-coated ultrasonic tips, and new #10 K-files for each canal (Fig. 1).
The extracted teeth were cleaned and stored for 24 hours in physiological saline solution to prevent dehydration and preserve their mechanical properties. The 30 molars were then embedded in numbered resin blocks to standardize the experimental procedures (Fig. 2).

Following preoperative CBCT analysis and under magnification control, cavity planning was performed according to pulp chamber anatomy, trephination depth, and the presence of potential calcifications. Initial access was performed in the mesial quarter of the central fossa using a #010 round diamond bur, following a conservative approach aimed at minimizing tissue removal compared with conventional access cavities. The access was progressively deepened until pulp chamber entry, while partially preserving the pulp chamber roof. Canal orifice location and finishing were then performed using ultrasonic tips and finishing burs to optimize dentin preservation, particularly in the pericervical region, and to avoid straight-line access to the apical third (Fig. 3).

Before negotiation of the mesio-buccal (MB) canal, an initial irrigation with 3% sodium hypochlorite was performed. Canal patency was achieved using pre-curved #10 K-files according to a standardized technique. Intermittent irrigation with 3% sodium hypochlorite combined with EDTA gel was used to improve canal access, reduce instrumentation stresses, and limit instrument fatigue.

In our study, these tools were essential. Magnification devices, particularly the operating microscope, improve the accuracy of canal orifice detection. **Boveda and Kishen** (2015) emphasized their importance in minimally invasive endodontics (33). **Gonçalves et al.** (2026), in a study on 72 mandibular premolars, demonstrated that magnification and ultrasonic tips significantly improved the detection of additional canals (39).

**Step 3: Postoperative CBCT evaluation:**

A postoperative CBCT scan with the file in place was performed to assess the effects of CACs and the stresses exerted on the #10 file. The analysis allowed evaluation of the cavity outline, the extent of pulp chamber roof removal, and the preservation of pericervical dentin.

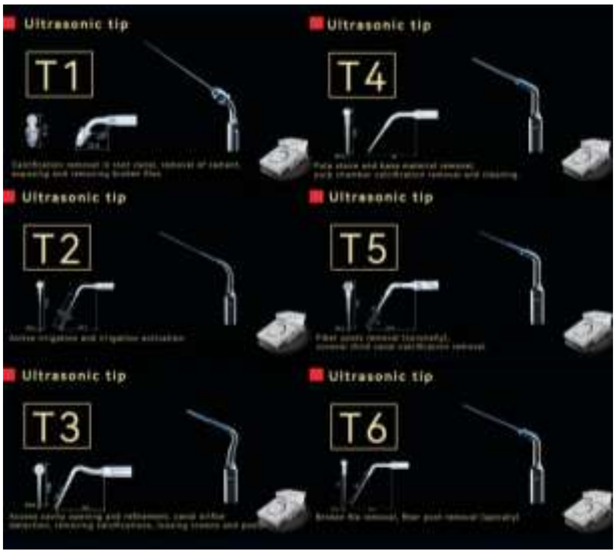


**Figure 1: Woodpecker Dr. Talal's Endo Kit ultrasonic tips. The T4 and T3 tips were used for the preparation of CACs in our study.**

**Figure 2: Set of selected teeth used for the preparation of CACs.**


**Figure 3**: 3D volumetric representation of micro-CT data showing the file access angle in the MB canals at the maximum curvature view for groups (A) TAC and (B) CAC. The blue line in (B) illustrates the different access angles after complete removal of the pulp chamber roof and coronal interferences (13).

**2.5 Data analysis**

Comparison of preoperative and postoperative CBCT scans was performed to evaluate the impact of conservative access cavities on endodontic access quality, preservation of dental structures, and #10 file fatigue. DICOM image analysis was conducted using the OnDemand3D software. Subsequently, Simpleware software was used to calculate the residual dentin volume after preparation of the conservative access cavities.

**2.6 Potential biases**

- **Sample selection:** Selection bias may occur if the molars are not representative of mandibular molars in the general population.
- **Operative techniques:** Instrumentation bias may arise if the wear of the instruments used is not uniformly controlled.
- **Measurements and analyses:** Measurement bias may be related to the accuracy of CBCT devices or image analysis software. Evaluation bias may occur if instrument fatigue criteria are not clearly defined or are subjectively interpreted.

## 3. Results

### 3.1. Demographic and descriptive data

The study included 30 extracted mandibular molars collected at the CCTD of Casablanca. The main reasons for extraction were advanced periodontal lesions (47%), prosthetic indications (33%), and orthodontic reasons (20%).

### 3.2. Preoperative measurements

Preoperative CBCT analysis showed a mean pulp chamber access distance of 2.5 ± 0.8 mm (2.1–4.2 mm), a mean pulp chamber floor-to-roof distance of 2.0 ± 0.5 mm (1.2–2.7 mm), and a mean curvature of the MB canal of 15° ± 10° (5°–35°). Axial, sagittal, and transverse sections were used to evaluate root canal anatomy and perform preoperative measurements. Teeth No. 7 and 8 were used as examples to illustrate the procedure (Table 1).

**Table 1: Initial measurements obtained from preoperative CBCT images of the 30 mandibular molars.**

| Evaluated parameters / Tooth | Pulp chamber access (mm) | Pulp chamber floor-to-roof distance (mm) | MB canal curvature |
|---|---|---|---|
| 1 | 3 | 1,5 | 10° |
| 2 | 2,8 | 2 | 20° |
| 3 | 3,8 | 1,8 | 35° |
| 4 | 4 | 2 | 5° |
| 5 | 3 | 1,6 | 32° |
| 6 | 2,4 | 2 | 13° |
| 7 | 3,3 | 1,5 | 34° |
| 8 | 3,5 | 1,2 | 5° |
| 9 | 3 | 1,4 | 10° |
| 10 | 3,7 | 2 | 32° |
| 11 | 3,3 | 2,2 | 8° |
| 12 | 3 | 1,5 | 15° |
| 13 | 2,5 | 2 | 13° |
| 14 | 3 | 2,2 | 20° |
| 15 | 3,2 | 1,7 | 10° |
| 16 | 2,9 | 1,5 | 5° |
| 17 | 3,1 | 2 | 31° |
| 18 | 3 | 2 | 32° |
| 19 | 3,5 | 1,6 | 11° |
| 20 | 3,7 | 1,5 | 25° |
| 21 | 2,9 | 1,7 | 10° |
| 22 | 4 | 2,2 | 8° |

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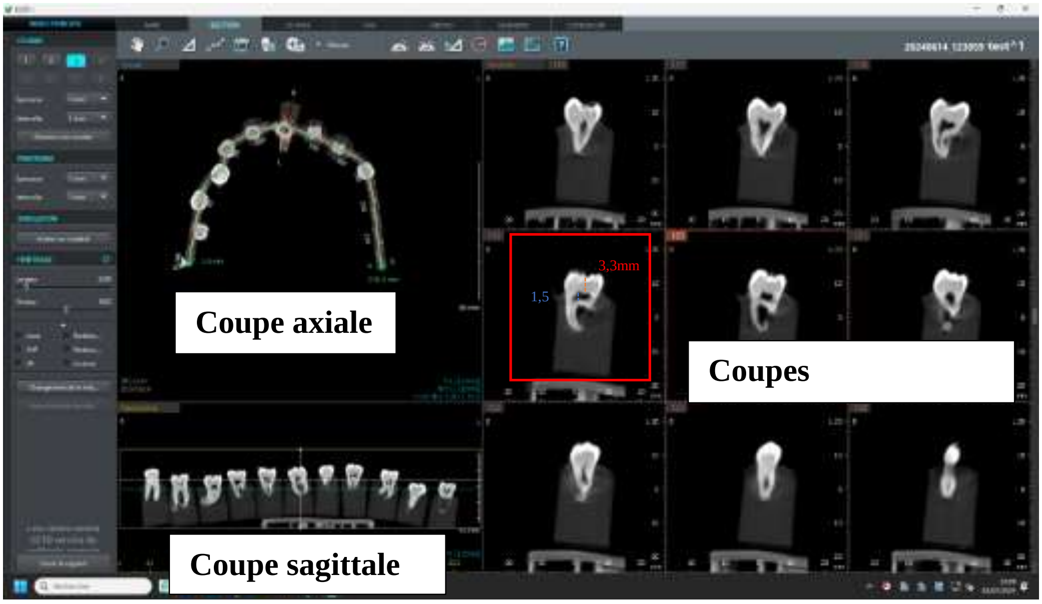
| | | | |
|---|---|---|---|
| 23 | 4,2 | 2 | 12° |
| 24 | 3,3 | 1,9 | 15° |
| 25 | 3,4 | 2,5 | 18° |
| 26 | 3,8 | 2,3 | 24° |
| 27 | 3,5 | 2,7 | 10° |
| 28 | 2,9 | 1,7 | 13° |
| 29 | 3,5 | 1,9 | 18° |
| 30 | 3,9 | 2 | 12° |

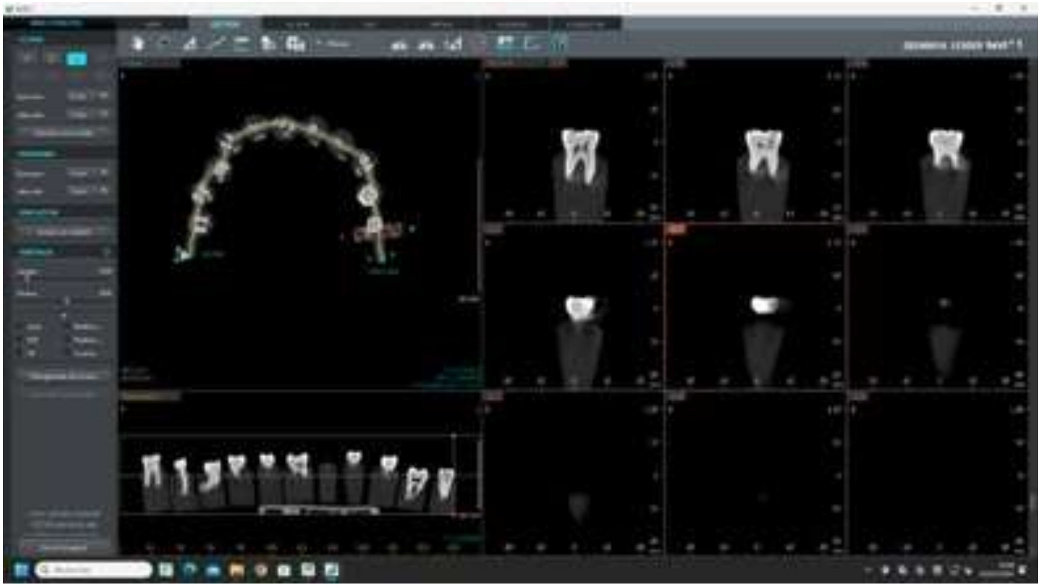
**Tooth 7:**

- Access distance to the pulp chamber: 3.3 mm
- Pulp chamber floor-to-roof distance: 1.5 mm
- MB canal curvature: 34°




**Tooth 8:**

- Access distance to the pulp chamber: 3.5 mm
- Pulp chamber floor-to-roof distance: 1.2 mm
- MB canal curvature: 5°



### 3.3. Evaluation of the residual dental structure:

**Preparation of CACs**

After radiological and coronal/radicular anatomical analysis, conservative access cavities were prepared without direct “straight-line” access. They included the pulp horns without additional extension, with partial or complete removal of the pulp chamber roof, while avoiding unnecessary divergence to limit cavity enlargement (Fig. 4).


**Figure 4: Example of prepared conservative access cavities.**

**Calculation of the residual dentin volume**

After acquisition of the two CBCT scans, image superimposition was performed using the Simpleware software. This software allows segmentation of the tooth into intact dentin and access cavity, enabling volume calculation in mm³. The difference between preoperative and postoperative volumes was then used to determine the residual dentin volume (Table 2).

**Table 2:** Residual dentin volume preserved in the 30 mandibular molars.

### 3.4. Analysis of instrument fatigue

| Evaluated parameters / Tooth | Residual dentin volume ($mm^3$) | |
|---|---|---|
| | Minimally invasive preparation (110 < residual volume < 150) | Slight over-preparation (Residual volume < 110) |
| 1 | 145.57 | |
| 2 | 138.44 | |
| 3 | 134.21 | |
| 4 | 142.36 | |
| 5 | | 87,99 |
| 6 | 136.97 | |
| 7 | 140.56 | |
| 8 | 132.67 | |
| 9 | 125.91 | |
| 10 | | 101,32 |
| 11 | 139.54 | |
| 12 | 133.47 | |
| 13 | 142.03 | |
| 14 | 147.12 | |
| 15 | | 93,45 |
| 16 | 140.22 | |
| 17 | 110.49 | |
| 18 | | 91,69 |
| 19 | 130.66 | |
| 20 | 135.29 | |
| 21 | 144.59 | |
| 22 | 129.43 | |
| 23 | | 88,97 |
| 24 | 139.80 | |
| 25 | 136.47 | |
| 26 | 147.95 | |
| 27 | 133.91 | |
| 28 | 131.28 | |
| 29 | 141.65 | |
| 30 | 144.21 | |
| Total | 25 teeth | 5 teeth |

K10 file fatigue was observed in all files without fracture. Twenty-four files (80%) showed slight visible deformation under magnification, whereas 6 files (20%) exhibited more pronounced deformation. No instrument fracture was recorded (Figs. 5, 6).

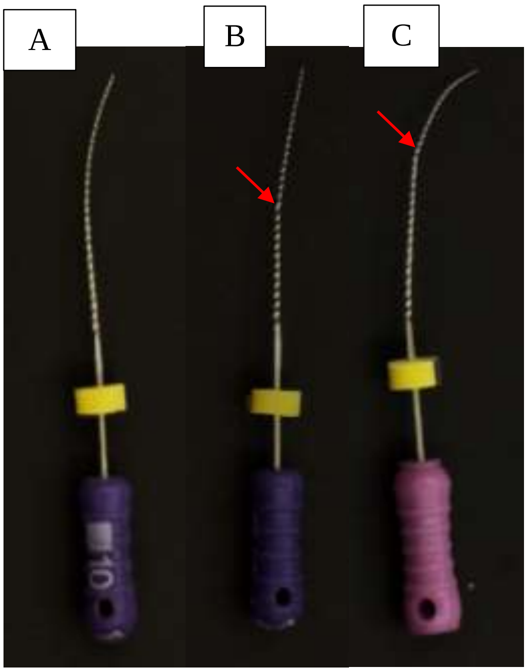
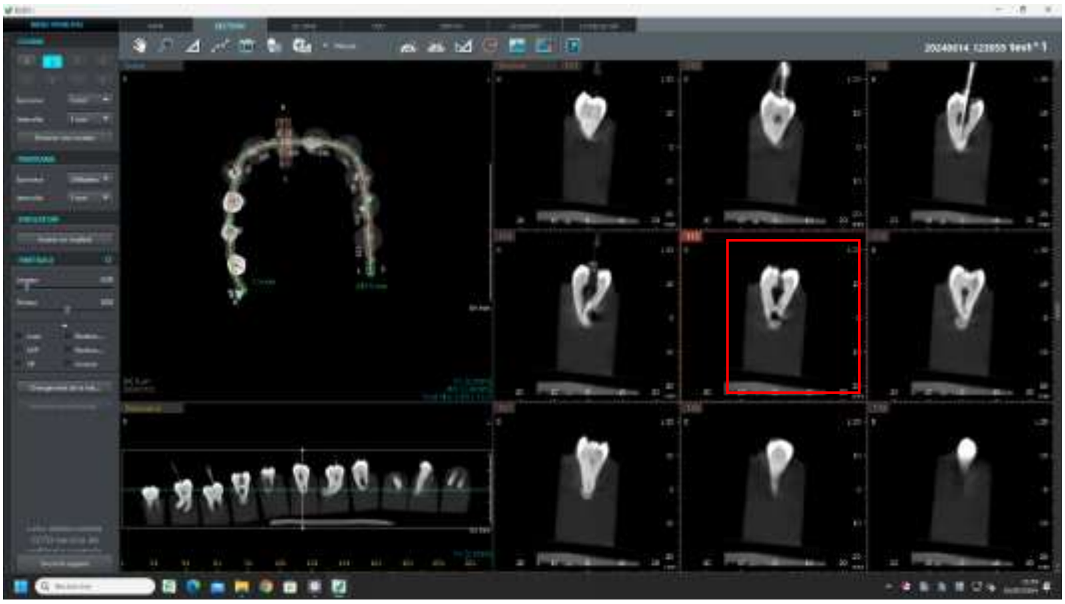



**Figure 5: A: File showing slight deformation; B and C: unwinding of the flutes in the middle third of the file.**

**Tooth 7:**



**Tooth 8:**

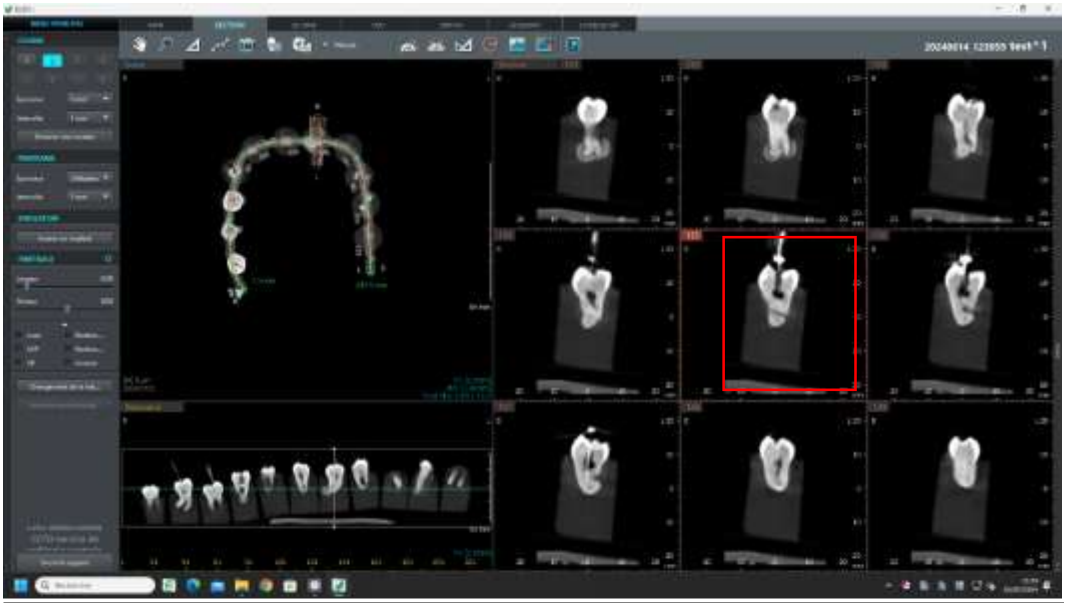


**Figure 6: Postoperative CBCT images of teeth 7 and 8 showing the prepared CACs with the insertion of the K10 file.**

### 3.5. Clinical implications

The effectiveness of Conservative Access Cavities lies in achieving proper access to the MB canal while minimizing dental tissue loss by preserving:

- Pericervical dentin
- Occlusal enamel-dentin tissues
- A portion of the pulp chamber roof, referred to as the "soffit" or "dentin roof strut" **(Figure 7)**

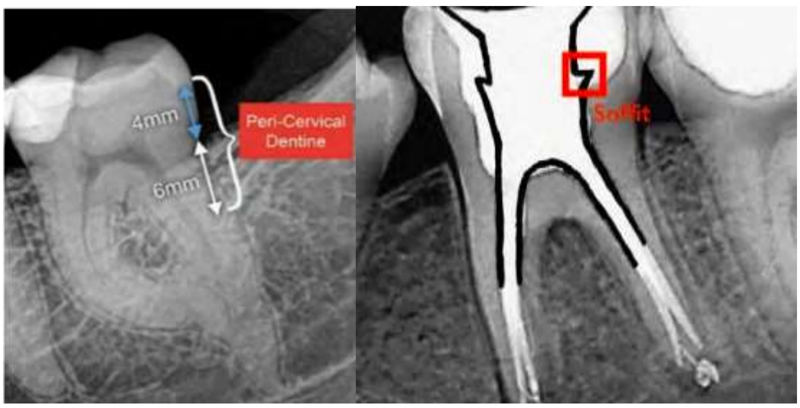



**Figure 7: Schematic representation of pericervical dentin and the soffit (36).**

## 4. Discussion

### 4.1. Discussion of the results

The preparation of CACs has long been dominated by traditional straight-line access, aiming to improve visualization and facilitate apical third instrumentation. However, modern techniques using high magnification allow reduction of cervical dental structure loss, while superelastic NiTi alloys facilitate the treatment of curved canals without the need for straight-line access (14). CBCT imaging has further supported this approach by enabling accurate and reproducible three-dimensional assessment of dentin and root canal volumes before and after preparation (15).

**4.2. Preservation of hard dental tissues and fracture resistance of CACs**

Following the preparation of CACs on 30 mandibular molars, our study demonstrated good preservation of dental tissues, with 25 teeth showing minimal structural loss and 5 teeth exhibiting slight over-preparation. The literature (16,17,18,19) suggests that CACs may improve fracture resistance compared to traditional access cavities.

**Patil et al**. (2022) (21) and **Plotin et al**. (2017) (37) also reported that CACs promote tooth preservation and may enhance fracture resistance compared to traditional access cavities.

Furthermore, **Juan Xia** et al. (2020) confirm that CACs result in lower dentin removal (3.85% ± 0.42%) compared to traditional access cavities (4.94% ± 0.5%), and provide better preservation of coronal structures. In addition, the mean fracture load of premolars did not differ significantly between CAC and TAC groups, and no significant difference was found in the fracture pattern ($P > 0.05$) (20).

**Overall, studies agree on better hard tissue preservation with CACs; however, findings regarding fracture resistance remain contradictory. These discrepancies may be explained by methodological differences (tooth type, equipment, operator experience, and testing protocols). Further in vitro studies are needed to clarify this relationship.**

**4.3. Localization of root canal orifices in CACs:**

Missing a canal is a frequent cause of persistent apical periodontitis (22,23), which highlights the importance of identifying all canal orifices from the outset. However, minimally invasive access cavities can make this localization more difficult due to reduced visibility.

In our study, the use of optical aids (operating microscope, especially magnifying loupes) as well as preoperative CBCT improved visibility and allowed the detection of all canal entries in the 30 molars, while also reducing the risk of over-preparation.

**Blauhut and Sonntag** (2020) (24) examined 84 extracted human molars assessed by 28 endodontic students. The results showed that in 30 teeth (35.7% of the total; 37.9% maxillary, 30.8% mandibular), the number of detected canals differed between CAC and TCA ($P < 0.001$), and that 152 canals (28.5% of the total; 26.6% maxillary, 33.6% mandibular) showed differences in the evaluation of their geometry ($P < 0.001$), confirming greater difficulty and potential misinterpretation with CACs.

**Saygili et al.** (2018) (27) demonstrated a higher detection rate of the MB2 canal with TCA (60%) and CAC (53.3%) compared to CAN (31.6%), partially confirming these findings.

In contrast, Rover et al. (2017) (25) and Mendes et al. (26) observed no significant difference in the detection of the MB2 canal between techniques (TCA, CAC, or variants) when magnification and ultrasonic tips were used.

**The concept of minimally invasive access preparation requires the integration of 3D imaging and an appropriate technical setup, as observed in our study. However, the difficulty depends on several factors related to the operator and the equipment used. Thus, further research is needed to determine whether the operator's prior knowledge influences the detection of additional canals.**

**4.4. Influence of CAC on instrument fatigue**

In our study, 24 K10 files showed slight modifications without significant signs of fatigue, while 6 files exhibited moderate unwinding, with no instrument fracture observed.

**Silva et al.** (2021a) (28) and Spicciarelli et al. (2020) (29) demonstrated that instruments used in minimally invasive cavities present lower cyclic fatigue resistance than those used in traditional access cavities. This reduction is thought to be related to an increase in canal curvature angle, generating higher stress and thereby increasing the risk of fracture (30) (Fig.8).

**Özyürek et al.** (2017) and **Barbosa et al.** (2020) also investigated instrument fracture and reported low fracture rates, but emphasized that the risk remains significant. The removal of a fractured fragment is associated with excessive dentin loss, thereby compromising the principle of minimally invasive preparation (30,31).

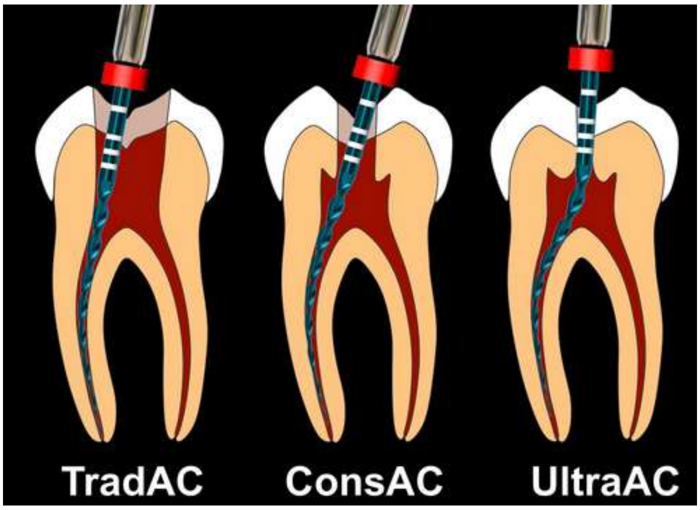



**Figure 8:** Schematic representation of endodontic files in TCA, CAC, and UAC. It can be observed that a higher curvature angle in the most coronal portion of the instrument is present in CAC and UAC, increasing the level of stress along the active part of the instrument and therefore the probability of fracture (30).

**The management of instrument fatigue is essential in endodontics, particularly when performing minimally invasive access cavities. Although these techniques help preserve dentin, they may reduce the durability of instruments. Careful monitoring of files and the use of EDTA gel are necessary to limit the risk of instrument failure and fracture. The combination of a conservative approach and proactive instrument management helps improve clinical outcomes and reduce complications related to instrument fatigue.**

### 4.5. Other challenges of CAC

The performance of conservative access cavities (CAC) in endodontics presents several technical challenges that may influence therapeutic success and long-term prognosis, particularly in the management of severely curved and calcified canals.

The use of CBCT has become essential for identifying such complex anatomies; however, the localization of calcified canals remains difficult and requires a high level of precision to avoid complications such as root perforations. **Buchgreitz et al.** (2016) emphasize that guided endodontics combined with CBCT enables more accurate localization of calcified canals, reduces the risk of complications such as instrument fracture, and improves long-term clinical outcomes (38).

These difficulties highlight the importance of rigorous preoperative planning as well as the use of advanced technologies (CBCT, operating microscopes) to optimize the outcomes of CAC and minimize complications.

## 5. Conclusion:

This study on 30 mandibular molars demonstrated good dentin preservation, with 5 cases of slight over-preparation and no instrument fracture. Optical aids, CBCT, and ultrasonic tips improved precision and tissue preservation. The results confirm the value of CACs and highlight the need for further research, particularly regarding fracture resistance.Advances in three-dimensional imaging and guide design have enabled the development of minimally invasive endodontic access and guided endodontic techniques. These approaches allow better anticipation of procedural difficulties, particularly in cases of pulp canal calcifications, while promoting more conservative and precise treatments. However, the risk of failure, ledges, or perforations remains, requiring strict adherence to the established protocol, careful control at each step, appropriate equipment, and the clinician's expertise.

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